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27 OCTOBER 1999

INVESTOR IN PEOPLE

09/830387

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1.	Your reference	98P4851/F21518/GB/R76/DA/rh
2.	Patent applicat *(The Patent Office* **9823396.8**	27 OCT 1998
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	ROKE MANOR RESEARCH LIMITED ROKE MANOR OLD SALISBURY LANE ROMSEY HANTS SO51 0ZN
	Patents ADP number *(if you know it)*	561545005
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM
4.	Title of the invention	METHOD OF AND APPARATUS FOR POWER CONTROL
5.	Name of your agent *(if you have one)*	DEREK ALLEN
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	SIEMENS GROUP SERVICES LIMITED INTELLECTUAL PROPERTY DEPARTMENT SIEMENS HOUSE, OLDBURY BRACKNELL, BERKSHIRE RG12 8FZ
	Patents ADP number *(if you know it)*	02898443005
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority application number *(if you know it)* / Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application / Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

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Continuation sheets of this form	-
Description	5
Claim(s)	-
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Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 26.10.98

D ALLEN (Their Attorney)

12. Name and daytime telephone number of person to contact in the United Kingdom — D ALLEN - 01344 396808

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METHOD OF AND APPARATUS FOR POWER CONTROL

The present invention relates to a method of and apparatus for power control, of the type used in a communication system, for example, in a spread-spectrum communication system, such as a Code Division Multiple Access (CDMA) communication system.

In a CDMA cellular communication system, power control is used to equalise signal to noise (S/N) ratios of the signals received at a base station from various mobile terminals. In the term 'signal to noise ratio', the term 'noise' is intended to include interference in the form of signals from other mobile terminals, as well as background noise.

A known technique involves measuring the S/N ratio in respect of signals received from a given mobile terminal over a measurement interval and comparing the measured S/N ratio against a desired threshold. If the measured S/N ratio exceeds the desired threshold, a binary 1 (or 0, depending upon the convention employed) is transmitted (within the plurality of signals transmitted from the base station) to the mobile terminal originating the given signal. If the measured S/N ratio is lower than the desired threshold, a binary 0 (or 1, depending upon the convention employed) is transmitted to the given mobile terminal. The mobile terminal, in turn, responds by reducing its transmission power by, for example, 1 dB if a 1 (or 0) is received or by increasing its power by 1 dB if a 0 (or 1) is received. In this way, the received signal to noise ratio is held approximately constant as path loss between the given mobile station and the base station varies and/or as the level of interference at the base station from other mobile terminals varies.

The above technique is effective in the transmission of continuous data where any transients associated with the initial setting of transmitter power at the mobile terminal can be ignored. However, where individual bursts (frames) of data are transmitted, for example packet data, the mobile terminal must set its initial transmitter power according to a so-called open loop power control technique. In this technique, the base station signals to the mobile terminal(s) the power at which the base station is transmitting; this can be either the total power received or the power of a particular signal which the mobile(s) station is receiving, and the interference level at the base station. The mobile terminal measures the power level of the corresponding signal received from the base station and uses the signalled information, i.e. the information relating to signal strength at the base station, to determine the power at which the mobile terminal must transmit in order to produce a required signal to noise ratio at the base station. On average, this should be the correct power. However, in many CDMA systems the frequency used for transmission from the base station to the mobile terminal (down-link) is different from the frequency used for transmission from the mobile terminal to the base station (up-link). Such a scheme is known as a Frequency Division Duplex (FDD) scheme. In an FDD scheme, propagation of signals is non-reciprocal in the short term, for example, multi-path fading on the down-link is uncorrelated with multi-path fading on the up-link. This effect can be mitigated somewhat by averaging the power measurements at the mobile terminal over the likely fading period. However, this does not cater for the instantaneous path level fluctuations in the up-link direction, resulting in the power transmitted by the mobile terminal being too high or too low at the start of the frame.

In a typical CDMA system, forward error correction (FEC) with interleaving is employed in order to mitigate the effects of fading and interference from other signals operating on the same frequency. If a known soft decision

decoding technique is employed, the effect of the interleaving is to make the probability of uncorrectable errors in an interleaved frame a function more of the average S/N ratio over the frame rather than, for example, the worst case S/N ratio. Consequently, if the S/N ratio at the start of a frame is too high, implementation of power control reduces the S/N ratio to the required threshold by the end of the frame, but the overall average will be higher than necessary. Conversely, if the S/N ratio at the start of a frame is too low, implementation of power control increases the S/N ratio to the required threshold by the end of the frame, but the overall average will be lower than necessary.

It is therefore an object of the present invention to obviate or at least mitigate the above described disadvantages.

According to the present invention, there is provided a method of power control in a communications system capable of transmitting a frame having a plurality of time intervals, the method comprising the steps of : selecting a time interval in respect of which a power level is to be determined; summing any previously measured power levels in respect of any time intervals preceding the selected time interval; determining the number of any remaining time intervals, and setting the power level in respect of the selected time interval based upon the sum of previously measured power levels and the number of remaining intervals in order to achieve a predetermined signal to noise ratio in respect of the frame.

Preferably, the power level is set during transmission of the frame in such a way as to tend to keep the received signal to noise averaged over the frame constant. This differs from known techniques which try to modify the power level within each time interval so as to substantially keep to the predetermined signal to noise ratio during each interval.

Preferably, the time interval is a time slot.

At least one embodiment of the invention will now be described by way of example.

A CDMA system comprises at least one base station arranged to communicate with a mobile terminal over a radio-frequency (RF) interface by transmitting a frame of data. The frame is transmitted from the mobile terminal to the base station, during which there are N adjustments of power corresponding to N time slots in the frame. For the first adjustment in the frame, a power threshold is set so as to be substantially equal to the required average S/N ratio at the base station. For the next and each of the subsequent adjustment, the power measurements made preceding the next and each subsequent adjustment are summed and the S/N ratio is determined based upon the assumption that if the determined S/N ratio is maintained throughout the remainder of the frame, the target for the average S/N ratio will be met.

For a power control interval range from 0 to N-1, the above technique can be expressed mathematically as follows.

Suppose we are about to set the power threshold for the j indexed slot. At a jth interval, the sum of power received at the base station during previous intervals can be generally expressed as: $\sum_{i=0}^{j-1}\gamma_i$, where the S/N ratio received in the ith interval is γ_i; the desired total S/N ratio sum over the frame is then $N\gamma_d$, where γ_d is the required S/N ratio.

N-j power control intervals therefore remain in the frame for which a power level is predicted. In order to satisfy the S/N ratio requirement over the entire frame, the predicted signal to noise ratios for the remaining intervals, γ_p needs to satisfy the following equation:

$$\sum_{i=0}^{j-1}\gamma_i + (N-j)\gamma_p = N\gamma_d$$

Thus, we can solve the above equation for γ_p to find the predicted required power level (and therefore the next threshold):

$$\gamma_p = \frac{N\gamma_d - \sum_{i=0}^{j-1}\gamma_i}{N-j}$$

Minor obvious modifications can be made within the normal ability of a skilled person to take account of non zero periods for measurement and for signalling within the power control sub-system.

If the S/N ratio received is higher than necessary at the beginning of a frame, then it will ideally be received at a level lower than the nominal S/N ratio by the end of the frame. Where multi-path fading occurs, none of the targets will be exactly met, but the use of this invention will result in smaller variation in average power over the frame, leading to an improvement in system capacity.

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